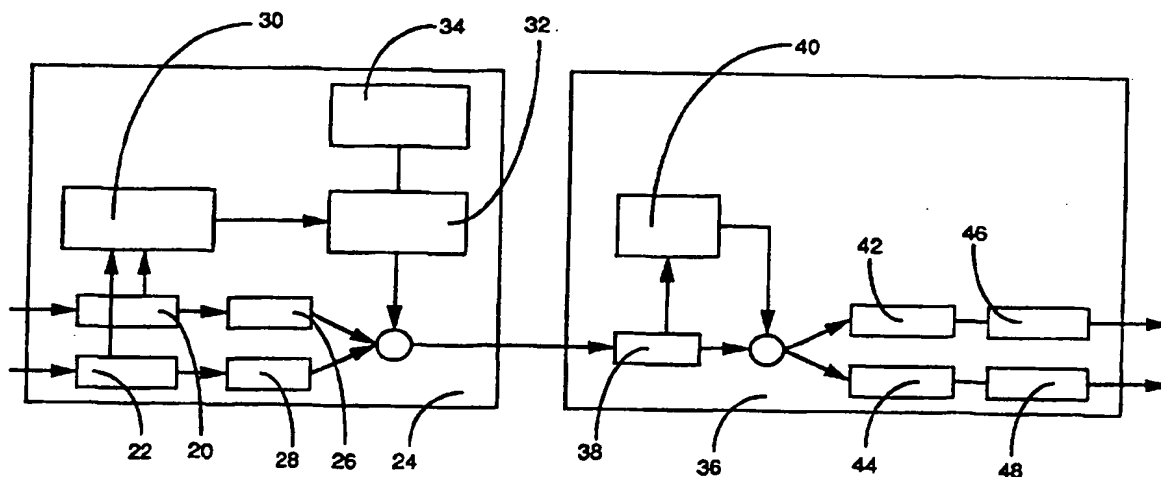




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04L 12/64, 12/56, H04Q 11/04	A1	(11) International Publication Number: WO 95/12265 (43) International Publication Date: 4 May 1995 (04.05.95)
(21) International Application Number: PCT/CA94/00554 (22) International Filing Date: 12 October 1994 (12.10.94) (30) Priority Data: 141,007 26 October 1993 (26.10.93) US (71) Applicant: NORTHERN TELECOM LIMITED [CA/CA]; World Trade Center of Montreal, 8th floor, 380 St. Antoine Street West, Montreal, Quebec H2Y 3Y4 (CA). (72) Inventors: ELLIS, John, G.; 56 Rosenfeld Crescent, Kanata, Ontario K2K 2H6 (CA). DYSART, Keith, C.; 50 Jarlan Terrace, Kanata, Ontario K2L 3L3 (CA). COMMONS, Douglas, N.; 2353 Tampa Avenue, Ottawa, Ontario K1H 7K2 (CA). (74) Agent: TOYOOKA, Yoshiharu; Northern Telecom Limited, Patent Dept., P.O. Box 3511, Station "C", Ottawa, Ontario K1Y 4H7 (CA).		(81) Designated States: CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>

(54) Title: DIGITAL TELECOMMUNICATION LINK FOR EFFICIENTLY TRANSPORTING MIXED CLASSES OF PACKETS

**(57) Abstract**

An efficient packet transport system for mixed traffic in which a packet fragmentation protocol allows traffic of different classes to occupy a single physical link. In one embodiment, packet fragmentation gives delay sensitive traffic priority over non-sensitive traffic. This allows both traffic types to coexist on a single data link. The protocol eliminates software overheads associated with misordered packets and efficiently transports both cell and frame formatted data using encapsulation.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo			SE	Sweden
CH	Switzerland	KR	Republic of Korea	SI	Slovenia
CI	Côte d'Ivoire	KZ	Kazakhstan	SK	Slovakia
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CN	China	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
CZ	Czech Republic	LV	Latvia	TJ	Tajikistan
DE	Germany	MC	Monaco	TT	Trinidad and Tobago
DK	Denmark	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali	UZ	Uzbekistan
FR	France	MN	Mongolia	VN	Viet Nam
GA	Gabon				

DIGITAL TELECOMMUNICATION LINK FOR EFFICIENTLY TRANSPORTING MIXED CLASSES OF PACKETS

Technical Field

5 This invention relates generally to high speed transmission of digital data in packets from one node to another. In particular, the invention is directed to a novel transmission technique by which digital data of different classes can be effectively transmitted through a single link.

10

Background Art

Multimedia is being touted as telecommunications of the future. Telecommunication networks are required to handle a variety of traffic such as voice, video, data etc.; in other words, the bandwidth must be shared by many different classes of traffic. However, different classes of traffic call for different qualities of service from the network, with respect to, for example, speed of transmission, probability of transmission error, network delay etc. As for the network delay, interactive data, voice and video traffic are delay sensitive and sensitivity is characterized by full duplex operation where users expect timely service. Considering the consequences of slow turn-around on customer satisfaction, slow interactive operations are deemed to be inadequate. Non-delay-sensitive traffic includes bulk down-load, non-real time video. This traffic can sustain relatively large delays because the end users don't see the delay. Typically, these services are simplex and delay is transparent to the user.

ATM and Fast Packet switching architectures are being proposed for integrated switching applications. These broadband technologies are characterized by cell switched data. The main advantage of cell switching is that it minimizes switching delays caused by voice/video/data interactions and it is suitable for hardware accelerated routing. Cell switching provides a predictable and controllable delay. Long data packets do not adversely interfere with delay sensitive voice packets.

Cell switching provides a connection oriented routing algorithm which prevents packet mis-ordering. By establishing an

explicit path, cells are guaranteed to arrive in sequence. Under normal circumstances, all cells associated with a connection follow an explicit path.

Cell switching effectively solves the emission delay and sequencing problem for connection oriented services, however, it is not well suited to connectionless data services. Packet switching connectionless data services over a broadband cell switch results in out of sequence cells due to multi-path delay variance. The re-assembly of out of sequence cells into packets poses a significant processing requirement on the network end stations. Furthermore, the transport of large (10-20 Kbyte) data packets requires processor intensive packet fragmentation into cells and re-assembly of cells into packets.

In the past, bandwidth sharing schemes have been proposed for integrated packet switching over a switching network. One scheme for an integrated voice and data network is described in U.S. Patent 4,914,650, issued on April 3, 1990 to Sriram. This network has a multiplexer arranged with a voice queue for storing received voice packets and a data queue for storing received data packets. Voice packets are transmitted for a predetermined interval T1 and data packets are transmitted for a predetermined interval T2. Predetermined intervals T1 and T2 may be of different duration. The multiplexer may be additionally arranged with a separate signaling queue for storing received signaling messages. If a signaling message is moved into the separate signaling queue during either interval T1 or T2, that interval is suspended and transmission of voice or data packets is interrupted from the end of a packet until the signaling message is transmitted. Then transmission of the interrupted voice or data packets is resumed for the remainder of the suspended interval T1 or T2.

The Sriram patent also states that alternatively a multiplexer may be arranged with a separate signaling queue for storing received signaling messages at any time. Signaling message transmission intervals are reserved either between intervals T1 and T2, between intervals T2 and T1, or both. These signaling intervals are of a flexible duration that is sufficiently long for transmitting all of the signaling messages waiting to be transmitted. The

5 multiplexer allocates a certain minimum bandwidth for voice and data traffic. This protects each type of traffic from congestion caused by the other type. Concurrently, the multiplexer also allocates to each type of traffic any spare bandwidth momentarily available because it is not being utilized by the other type of traffic. Signaling messages are serviced with very low delay and zero packet loss.

10 In U.S. Patent 4,707,831, issued November 17, 1987 to Weir et al, an electrical intelligence transmission system is described. In the system, both speech and data are transmitted as packets over virtual connections set up in a fully digital network, the speech and data packets being transmitted at the bit rate of the transmission medium in which speech packets have priority over data packets. If a speech packet is detected during the transmission of a data packet, the transmission of that data packet is interrupted to allow the
15 speech packet to be conveyed over the transmission medium, and when the medium again becomes free of speech, the non-transmitted part of the interrupted data packet is transmitted as a separate packet.

20 In the system of Weir et al, both speech and data are transmitted as packets over virtual connections set up in a fully digital network. A virtual connection is set up from a calling party to a called party at a call setup. Each packet contains source address, destination address, routing information of the switching network etc., in addition to payload and other network management
25 information. Each packet stays intact while being transported through the network except for network management information and routing information. Each packet is transmitted through the network to the destination along the route specified in the routing information. Therefore, if the customer desires to send voice to a destination while data packets are being transmitted to a different destination over the same loop, the voice packet must interrupt the transmission of data packets because it requires minimum delay.
30 The patent achieves this by adding a tail to the interrupted data packet and storing the remaining un-transmitted part of the data packet in a buffer. Like a data packet, a voice packet also contains addresses, routing information etc., but is 64 bytes long instead of
35 1024 bytes for a data packet. While the data packet is being

interrupted, the voice packet must seize a channel in a synchronous TDM slot and is transmitted immediately when one is found. When the loop becomes available, the remaining part of the data in the buffer is sent as a separate packet containing addresses, routing information etc. In the patent, transmission is byte oriented and requires byte overheads because of channelized (timeslotted) design. As described above, packets are transported through a virtual connection from end to end. Therefore each packet must contain addresses, routing information, etc. The patent does not support multiple interruptions of a data packet. This means that the patent cannot guarantee delay of high priority packets. For example, if a link has a 16K packet to emit and is stopped after only 1 data byte is emitted in order to insert voice, 64 bytes of voice are now emitted and the remaining 15,999 bytes of data must then be played out, which will also delay any future voice packets. Because the patent limits the data packet to 1K and voice to 64 bytes, this may not be a problem for a loop circuit. However, in a high density network, this technique cannot be used without severe performance restrictions.

20 Objects of the Invention

It is therefore an object of the present invention to provide a method and apparatus for transporting mixed traffic of different classes from one node to another over a single link.

It is another object of the present invention to provide a method and apparatus for transporting mixed traffic of different classes from one node to another over a single link in which one class of traffic can interrupt the emission of the other.

It is yet another object of the present invention to provide an integrated cell switching network which can handle connection oriented as well as connectionless packet switching of mixed traffic of different classes.

Disclosure of Invention

Briefly stated the present invention is directed to a digital telecommunication system for serially transmitting in packets of various sizes digital data of two or more different priorities from a source card to a destination card over a link. The system comprises

the link connecting the cards, each of the cards having two or more buffers, each buffer being assigned with a priority for individually buffering packets of digital data according to their priority. A link controller serves the buffers for transmission of a packet buffered therein to the destination card according to their priorities so that a packet of one priority in its assigned buffer is able to interrupt the transmission of a packet of other priorities from their respectively assigned buffers and to fragment it to one or more packet fragments. The link controller adds to each of the packets and the fragments, a flag, priority bits, sequence bits, a complete bit and CRC bits.

According to another aspect, the present invention is directed to a method of serially transmitting in packets of various sizes digital data of two or more different priorities over a link from a source card to a destination card contained in a digital telecommunication system. The method comprises steps of individually buffering, at each card, packets of digital data according to their priority in two or more respectively assigned buffers, and serving the buffers at the source card for transmission of packets to the destination card according to their priorities so that a higher priority packet in a higher priority buffer interrupts at any time the transmission of a lower priority packet from a lower priority buffer by fragmenting the lower priority packet into one or more packet fragments. The method further includes a step of adding to each of the packets and the fragments, priority bits, sequence bits, and a complete bit to indicate respectively the priority, sequence number and completeness of each packet.

Brief Description of the Drawings

For a more complete understanding of the present invention and for further objects and advantages thereof, reference may now be made to the following description, taken in conjunction with the accompanying drawings, in which:

Figure 1 is a schematic illustration of a telecommunication network in which links or trunks are shown to connect a switching node. The present invention is applied to the links.

Figure 2 is a schematic block diagram of a link connecting a source card and a destination card.

Figure 3 is an illustration of data flow from buffers to a link.

Figure 4 is a protocol format according to one embodiment of the present invention.

Figure 5 shows in more detail the source and destination
5 cards.

Mode(s) of Carrying Out the Invention

Figure 1 shows a schematic illustration of a typical network application using a novel link protocol which is designed to
10 transport a payload from a source card 10 to a destination card 12 and which includes packet fragmentation capability. The network is formed by more than one switching node 14 connected by links or trunks 16. Switching (packet, circuit, cell etc.) takes place at each node 14 and is outside the protocol of the present invention. In the
15 embodiment, mixed traffic such as, for example, voice and data is transported over a link in which voice traffic has higher priority over data traffic because of the shorter delay requirement. However, it should be noted that more than two classes of traffic can be handled, each having a differing priority based on other
20 criteria or preferences than the delay requirement.

Referring to Figure 2, two queues 20 and 22 are provided at the source card 24 on the left to store the packeted data to be transmitted. These queues are followed by buffers 26 and 28 which store packets or partially disassembled packets, as the case may be.
25 The buffers 26 and 28 are serviced on a first come first served basis, however, the high priority buffer 26 is always serviced before the low priority buffer 28, in fact, the high priority buffer will pre-empt the low priority buffer whenever any high priority packets are waiting to be sent. A priority encoder 30 reads the priority of packets
30 stored in the queues. Packets serviced out of the queues are first stored in respective buffers 26 and 28 waiting for a header and a tail to be appended. A header generator 32 receives priority indication from the priority encoder 30 and other information such as sequence number, flag, CRC etc. from the emission context 34 and
35 attaches the header and tail to each packet. If no packets are queued to be sent, the flag delimiter is sent. In practice, the priority encoder

30, buffers 26 and 28, header generator 32 and emission context 34 are built into a custom ASIC.

The disassembly process begins when a low priority packet is temporarily suspended while a high priority packet is emitted.

5 High priority packets will continue to be emitted as long as the high priority transmit buffer has data to send. When the high priority buffer is emptied, the low priority packet is restarted and the remainder of the low priority packet is sent. It is possible for a low priority packet to be interrupted as often as required and to be
10 fragmented to any size, depending on the arrival of high priority packets at the transmit queue.

At the destination card 36, the received packets or fragmented packets are stripped off the header at a header reader 38. A protocol checker 40 monitors the priority and sequence number of the
15 packets and directs them to their respective buffers 42 and 44 which are followed by queues 46 and 48. Low priority packets are assembled while high priority packets are simply queued. High priority packets are never fragmented, therefore they need not be assembled or disassembled.

20 Figure 3 shows the form of the link data stream according to the present invention. Data is depicted as moving from right to left, that is, the bits on the left are emitted first. On the left, a low priority packet D1 has been started and then a high priority packet D2 interrupts it. The low priority packet is fragmented and its
25 transmission is suspended until all high priority packets have been sent. Once the high priority packets have been sent, the low priority packet is resumed. However, another high priority packet D3 arrives at t1 after the end of D2 and thus it also interrupts D1. After D3, D1 is resumed until all the remaining packet fragments have
30 been sent. Note that each fragment is delimited by a flag F.

Figure 4 shows in detail the protocol according to one embodiment of the present invention. As mentioned earlier, this is a link protocol which is designed to transport a payload from a source card to a destination card. In this embodiment, the protocol
35 defines a packet transport system with two delay classes. The format of the protocol is based on the HDLC format with the addition of a new 1-bit field (Priority) and 4-bit field (SEQuence) between the

opening flag and the payload and a new 1-bit field (Complete) immediately before the CRC field. The first 1-bit field identifies the priority of the packet as HIGH (1) or LOW (0). The four-bit field identifies the sequence (SEQ) number. The one-bit field (C) added at
5 the end of the payload indicates whether the packet is complete (1) or will be continued (0) in the subsequent packet. The above protocol in this embodiment supports two levels of priority (P). A low priority packet may be interrupted by one or more high priority packets; a high priority packet may not be interrupted. The
10 complete bit (C) will always be set to one (1) for a high priority packet. It should of course be noted that any number of priority levels may be provided at the expense of hardware and software complexity. It should also be noted that the description thus far refers to the priority levels of traffic with respect to their delay
15 sensitivity. However, traffic can be categorized according to other criteria and the priority field of the protocol can be used to treat certain traffic preferentially over others.

The sequence field (SEQ) contains a four-bit number, sent LSB first, whose value in each packet of high priority data or each
20 packet fragment of low priority data should be one greater than the sequence number of the previous packet. The sequence number will roll over from 15 to 0. This sequence number is used to determine if packets are repeated or skipped whenever a high priority packet interrupts a low priority packet. Whenever a packet
25 is repeated or skipped as indicated in SEQ, all low priority packets or packet fragments following the high priority packet will be discarded.

The packet fragmentation protocol of the present invention is bit oriented and can be used on any transparent link facility.
30 Additionally, it is possible to use this protocol on DS1/E1 facilities where bit stuffing may be required to maintain the ones density. Zero bit insertion and deletion are applied outside the packet fragment protocol and as a result are transparent. The protocol of this invention allows delay sensitive packets to be routed with a
35 predictable store and forward delay. Delay sensitive packets are emitted in preference to non-delay sensitive packets. The protocol provides error protection in the form of CRC and sequence

numbers, incorrect fragments are marked as bad (stored in the block descriptor) and are discarded by software. In the worst case, the protocol overhead on the packet fragments is 46 bits per payload, excluding flag bits.

5 The source and destination cards are shown in detail in Figure 5. The transmitter data path for the protocol generation according to one embodiment of the present invention is shown on the left. A memory 50 stores different categories (or priority) of data to be transmitted at different locations, that is to say, in the present
10 embodiment the memory can be partitioned to a high priority queue and buffer for high priority data, and a low priority queue and buffer for low priority data. Of course, separate queues and buffers may be provided for different categories of data. A transmit control block 52 generates the timing, which signals by a line 54 a
15 staging register 56 and data register 58 to properly align 8-bit words of payload data to transmit. The transmit control block 52 also signals a protocol/seq block 60 to insert the new bit fields (priority, sequence and complete fields) which have been described above into payload data at the appropriate time to form TXDATA 62. The
20 protocol/seq block 60 consists of priority (P) and complete (C) 1-bit storage registers 64 and 66, sequence generator (SEQ) 68 which is a 4-bit parallel in/serial out storage register, and 4-bit incrementer 70. The transmit control block 52 receives the priority of payload data stored in the common memory 50 and sends it to the priority
25 register 64. The sequence generator 68 and incrementer 70 count up and insert the sequence number of packets. The sequence number rolls over from 15 to 0.

 As described earlier, immediately following transmission of the opening flag, the priority (P) and sequence (SEQ) bits are
30 transmitted over TXDATA. The payload immediately follows this opening bit field provided via the data register 58. Whenever a low priority packet is interrupted, the complete (C) bit is set to 0, indicating the current packet has been interrupted and is incomplete.

35 The control and protocol/seq blocks are brought to a known state whenever the reset input is asserted. During reset, priority (P), complete (C) and sequence (SEQ) bits are set to 0. This is a

synchronous circuit relative to CLK. Input priority and EOP (End-Of-Packet or Complete) are synchronously updated to the priority and complete storage registers. The combination of the sequence generator and incrementer generates the sequence number for each transmitted packet. The control block provides control via
5 combinational logic and a finite state machine to properly insert the additional fields into the protocol.

Figure 5 also shows the receive data path on the right. The receiver control block 72 generates the timing which signals the
10 protocol/seq checking block 74 to extract the added bit fields from RXDATA at the appropriate time. Immediately following reception of the opening flag at flag detection 76 and data register 78, which are timed by the timing signal from the control block 72, the priority (P) and sequence (SEQ) bits are extracted from RXDATA and sent to
15 the protocol/seq block 74. The payload immediately follows the opening P and SEQ bit fields and is diverted to the common memory 80 via the 8-bit staging register 82. The protocol bits are tested at protocol/seq block 74 for a priority change (P), an out of sequence error in the sequence field (SEQ), and an incomplete or
20 interrupted packet indicated by the complete (C) field. The protocol/seq block 74 consists of 4-bit storage registers OLD SEQ 84 and SEQ 86, 1-bit storage registers for Priority 88 and Complete 90, and a 4-bit comparator 92.

The control and protocol/seq blocks are brought to a known
25 state whenever the reset input is asserted. During reset, storage registers OLD SEQ 84, SEQ 86, Priority 88 and Complete 90 are set to 0. This is a synchronous circuit relative to CLK. The control block provides control via combinatorial logic and a finite state machine to properly extract the added fields from the input RXDATA. The
30 comparator 92 determines if a packet has been skipped or repeated by monitoring the number in the SEQ field. This information will be stored for later processing.

Repeated Fragment

The protocol checker at the destination card detects repeated
35 fragments whenever the sequence number of an arriving packet fragment is 1 to 4 smaller than expected. The checker discards all repeated packet fragments. When the packet fragment with the

expected sequence number arrives, the checker passes the packet fragment to its respective buffer.

Skipped Fragment

The protocol checker detects skipped packet fragments
5 whenever the sequence number of an arriving packet fragment is 1
to 4 greater than expected. If a skipped packet fragment is detected,
the protocol checker will update its expected sequence number so
that it equals the sequence number of the latest packet fragment that
has arrived. The protocol checker will use the new sequence
10 number when testing all subsequent packet fragments.

Whenever a skipped fragment error is indicated, the upper
layer packet protocol should perform a packet level CRC check on
the latest packets received. The packet level CRC is required in
order to determine if the packet has lost data. Fragment level CRCs
15 are insufficient for determining if a lost fragment has occurred.
Note the high priority packets are entirely encapsulated within a
fragment, therefore the fragment level CRC is equal to a packet
level CRC (only for high priority packets).

Replicated or lost packet fragments can occur when using
20 DS1/E1 facilities which use frame slips to adjust small differences
between the receive and transmit clock frequencies. When a DS1
transmitter is sending data slightly faster than the receiver,
overruns will occur. To prevent overruns, the transmitter
periodically deletes a frame of 24 bytes (193 bits). The deletion of 24
25 bytes may cause the loss of entire packet fragments; this occurs if the
fragment fits entirely within the 24 byte slip. Without sequence
numbers, this loss would go undetected.

When a DS1 transmitter is sending data at a rate slightly less
than that of the receiver, then the receiver would underrun. T1
30 facilities introduce an extra 24 byte frame of data to prevent
underruns. The added frame is a replica of the previous frame,
therefore there is a potential to replicate entire packet segments.
The protocol sequence numbers detect fragment replication.

Based on a minimum payload size of three bytes (2 bytes of
35 address and one byte of data) the minimum packet fragment size is
38 bits. This assumes that there is no CRC and that the interface
does not perform zero stuffing. When a T1 frame is replicated, 193

bits are replicated and therefore there is the potential to replicate as many as 5 packet fragments (193 divided by 38). For the protocol to uniquely identify the replicated fragments, at least 11 sequence numbers are required (Nyquist criteria). An 11 state sequence
5 number will prevent packets from aliasing due to the modulus counter wrapping. Given that the protocol of the present invention is bit oriented, the logical sequence number size has been selected as 16, which is the smallest binary sequence number greater than 11.

The packet fragment contains an octet aligned payload that is
10 being sent from a source card to a destination card. The payload consists of a user packet which may include a software routing address. Leading bytes of the first fragment payload are used by the software routing system to route the user data. The length of the payload is an integer number of bytes. The protocol according to the
15 present invention breaks the packet into octet aligned fragments that are actually transported in the payload field. The payload carried in a fragment may include the entire packet or some part of the packet, depending upon whether or not fragmentation has occurred. High emission priority packets always contain the entire
20 user packet in the payload.

The delay that a particular packet fragment experiences is based on the packet length divided by the link speed. High emission priority packets should be length limited so that the emission delay does not exceed the maximum packet delay that is tolerable for high
25 priority data.

Packets within the broadband network are of fixed or variable length. In order to maintain a reasonable switching delay for voice and video applications, two maximum packet sizes are used in the present invention. Voice and video packets will have a maximum
30 packet size that ensures minimal switching and assembly delays, while data packets will have a larger maximum packet size reflecting their insensitivity to delay. The maximum packet size can be, for example, approximately 64 bytes for high priority data, and 16 Kbytes for low priority data. However, these numbers are
35 examples only and in practice the maximum packet sizes are calculated based on link speed. Therefore, it is possible to use

different packet sizes for different links among nodes in a network where some links are faster than others.

Voice delay is maintained by keeping the voice packet size small relative to the link speed. Interrupting low priority data
5 packets effectively fragments the packet being transported, requiring the destination to reassemble packets. Fragmentation also introduces the potential for fragment mis-ordering. This undesirable characteristic is eliminated in the present invention by only allowing packets to be fragmented on a trunk or link. A single
10 link acts like a first-in first-out buffer in which mis-ordering is not possible.

WHAT IS CLAIMED IS:

1. In a digital telecommunication system for serially transmitting packets of digital data of various sizes in two or more different priorities from a source card (24) to a destination card (36) over a link (16) in which each card has two or more buffers (26 and 28) and each buffer is assigned with a priority for individually buffering packets of digital data according to their priority; the invention being characterised in that
10 a link controller at the source card serves the buffers for transmission of packets therein to the destination card according to their priorities so that a packet of higher priority in its assigned buffer is able to interrupt at any time the transmission of a packet of lower priority from its assigned buffer and to fragment it to one or
15 more packet fragments; and
the link controller adds to each of packets and the fragmented packets, priority bits, sequence bits, and a complete bit to indicate respectively the priority, sequence number and completeness of each packet and fragmented packet.
20
2. The digital telecommunication system according to claim 1, further comprising:
a protocol checker (74) at the destination card for monitoring the sequence numbers of packets for skipped or replicated packet
25 fragments.
3. The digital telecommunication system according to claim 2, wherein each card further has two or more queues (20, 22, 46 and 48), each queue being connected to each of the buffers and being
30 assigned with respective priority for storing packets of digital data according to their priority.
4. The digital telecommunication system according to claim 3, wherein the link controller comprises:
35 a priority encoder (30) connected to the queues for reading the priority of packets stored therein;

a header generator (32) for adding to each of the packets and the packet fragments a flag, priority bits, sequence bits, a complete bit and CRC bits; and

5 a transmission control (34) for coordinating the priority encoder and the header generator.

5. The digital telecommunication system according to claim 4 further comprising a common memory which is properly partitioned to be used for the queues and buffers, each assigned to a
10 different priority.

6. The digital telecommunication system according to claim 4 wherein a packet length is of any size within the respective maximum length for each priority, which maximum length is
15 determined by the speed of the link.

7. In a digital telecommunication system for serially transmitting packets of digital data of various sizes in two or more different priorities from a source card (24) to a destination card (36)
20 over a link, the telecommunication system comprising two or more buffers (26, 28) for individually buffering packets of digital data according to their priority, the invention being characterised in a method of interrupting transmission of data packets of one priority by data packets of a different priority in that;

25 serving the buffers at the source card for transmission of packets according to their priorities so that a higher priority packet in a higher priority buffer interrupts at any time the transmission of a lower priority packet from a lower priority buffer by fragmenting the lower priority packet into one or more packet fragments; and
30 adding to each of packets and packet fragments, priority bits, sequence bits, and a complete bit to indicate respectively the priority, sequence number and completeness of each packet and packet fragment.

35 8. The method of serially transmitting digital data according to claim 7, comprising a further step of:

receiving serially at the destination card packets transmitted over the link;

individually buffering received packets and packet fragments according to their priority at their respectively assigned buffers; and

5 monitoring the sequence bits of the packet fragments for the correct sequence of the packet fragments.

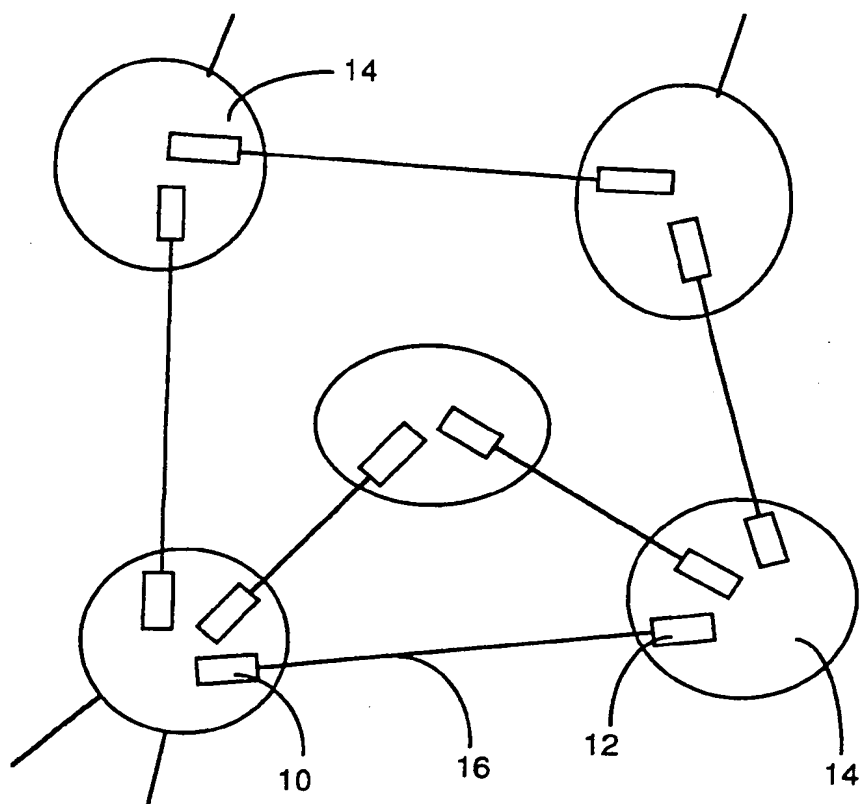
9. The method of serially transmitting digital data according to claim 7, wherein the step of serving the buffers at the source card for
10 transmission of a higher priority packet is performed whenever there is a packet to send in the respective buffer, thus interrupting the transmission of a lower priority packet each time a higher priority packet is transmitted and fragmenting it into one or more packet fragments of any size.

15

10. The method of serially transmitting digital data according to claim 9, further comprising a step of:

storing packets of digital data in respective queues according to their priority prior to the step of individual buffering.

1/4

**Fig 1**

2/4

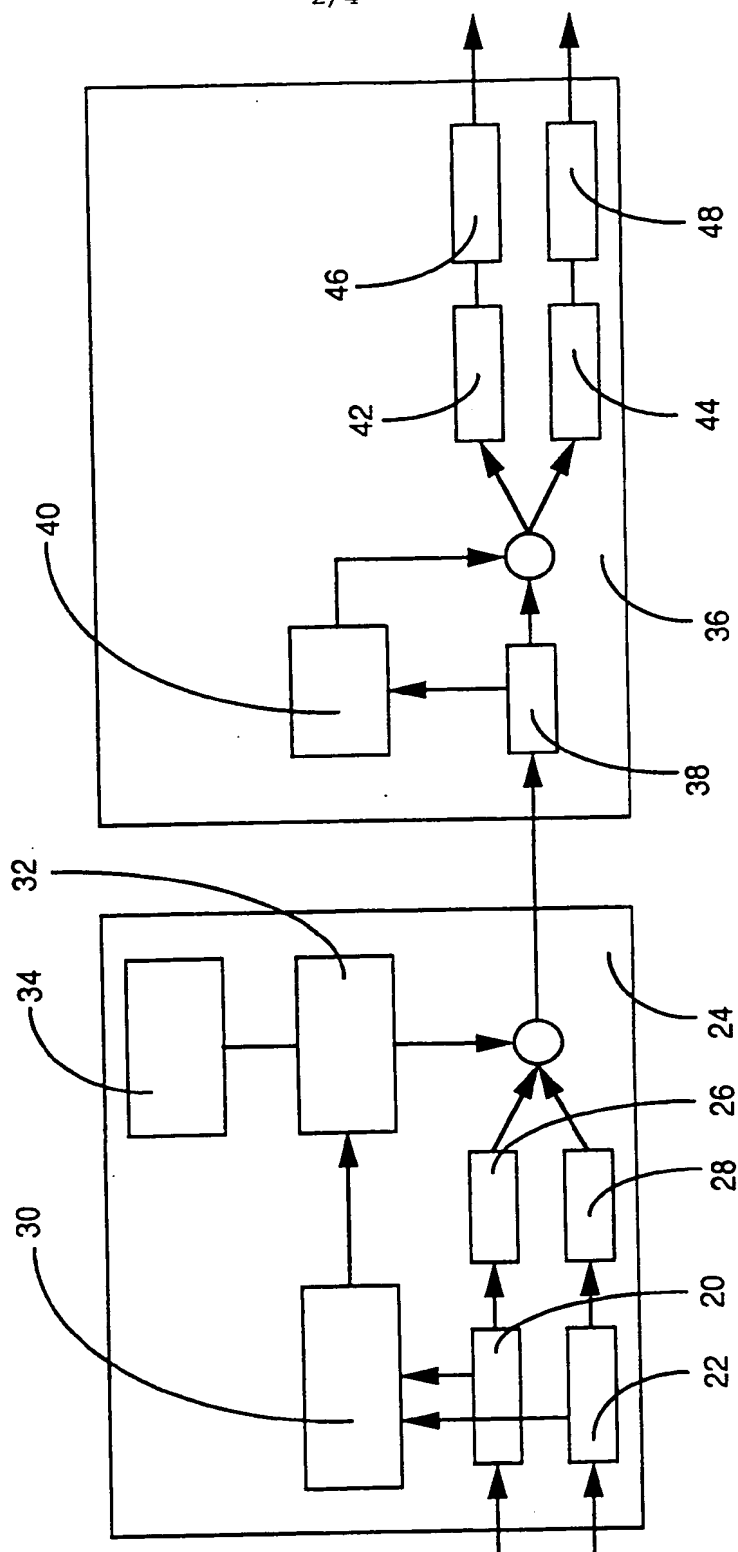
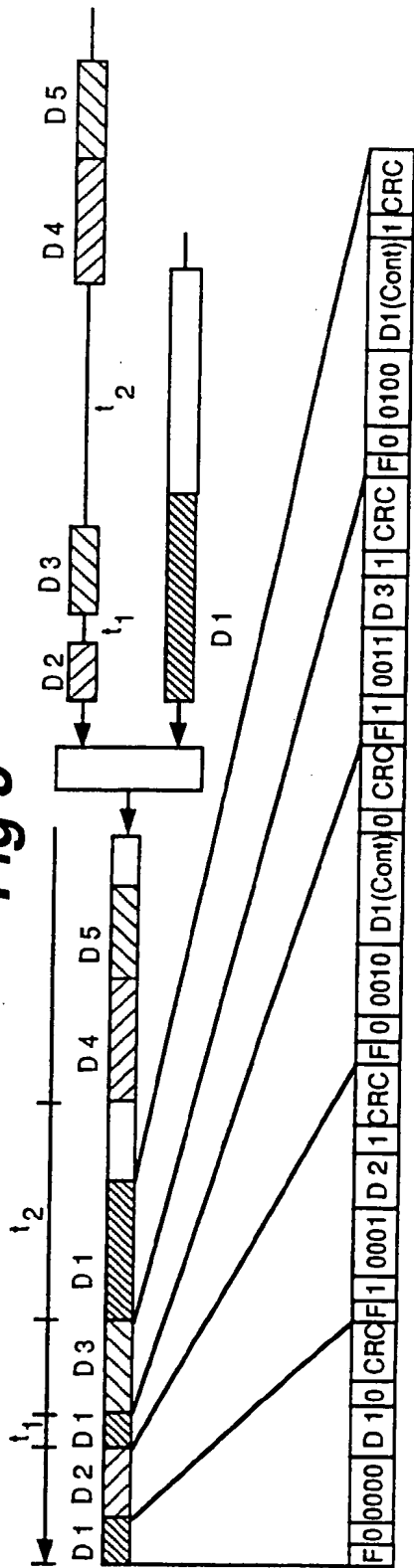


Fig 2

Fig 3

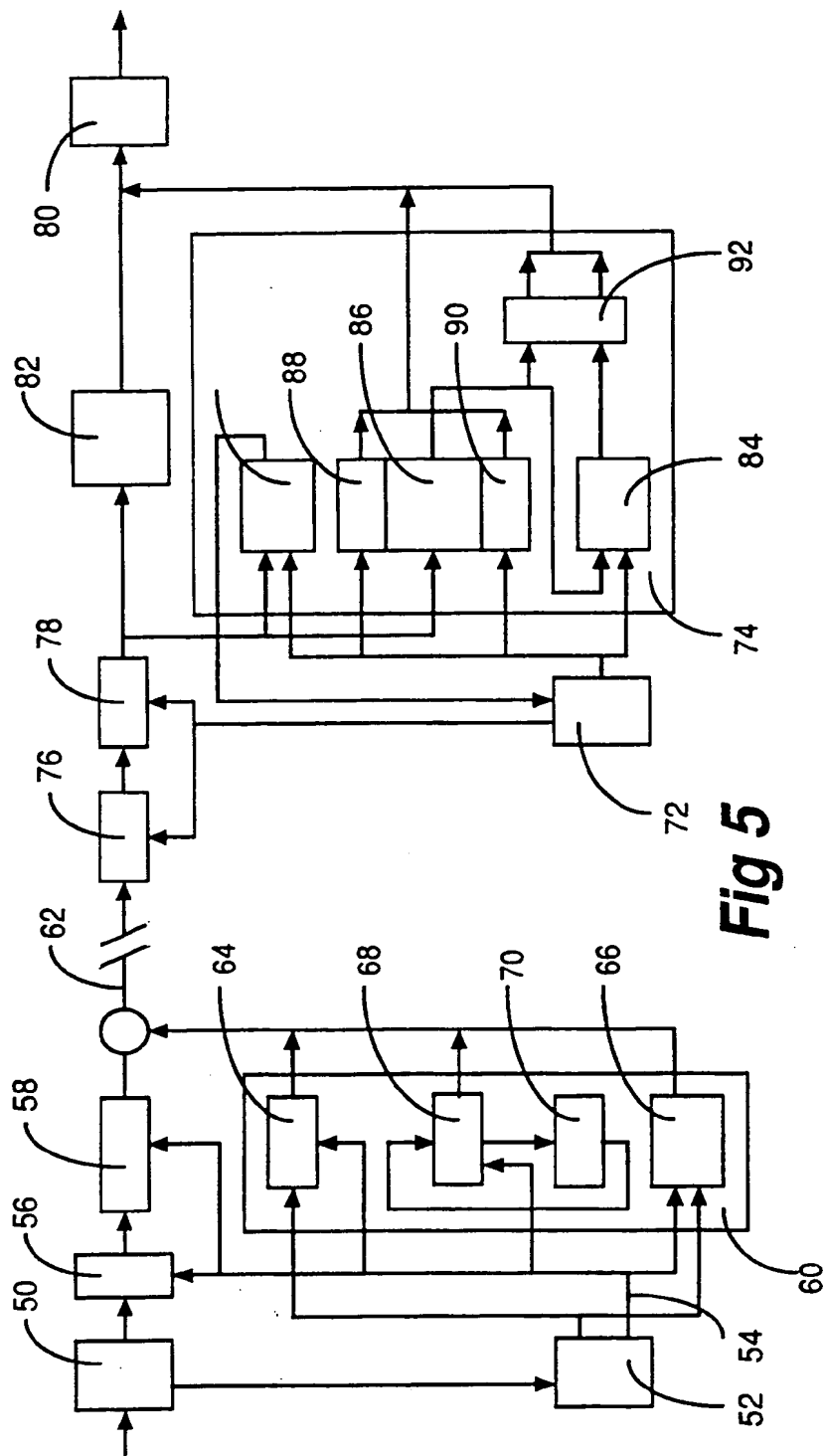


Protocol Diagram

8	1	4	N x 8			1	0, 16, 32	8
Flag	P	SEQ No.	Payload, (Address, Control, data)			C	CRC	Flag

N = the number of bytes in the payload

Fig 4



INTERNATIONAL SEARCH REPORT

Intern al Application No

PCT/CA 94/00554

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 6 H04L12/64 H04L12/56 H04Q11/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 6 H04L H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 276 349 (INTERNATIONAL BUSINESS MACHINES) 3 August 1988 see page 3, line 48 - line 50 see page 4, line 1 - line 34 see page 5, line 2 - line 15 see page 6, line 7 - line 20	1,7
A	---	2,3,8-10
Y	EP,A,0 435 046 (ALCATEL N.V.) 3 July 1991 see abstract see column 4, line 4 - line 30	1,7
A	---	2,8
A	EP,A,0 320 772 (STANDARD ELEKTRIK LORENTZ) 21 June 1989 see column 6, line 14 - column 12, line 16; figures 5,10 ---	1,7
	--- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

& document member of the same patent family

Date of the actual completion of the international search

24 January 1995

Date of mailing of the international search report

0 2. 02. 95

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+ 31-70) 340-3016

Authorized officer

Staessen, B

INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 94/00554

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,93 01670 (CODEX CORPORATION) 21 January 1993 see abstract ---	1,3,4,7, 9,10
A	IEEE TRANSACTIONS ON COMMUNICATIONS, vol.41, no.1, January 1993, NEW YORK US pages 237 - 245, XP367768 N. ENDO ET AL. 'Shared Buffer Memory Switch for an ATM Exchange' see page 240, left column, line 21 - line 34 see page 240, right column, line 17 - line 25; figures 5,7 ---	1,2,7,8
A	IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS '93, 23 May 1993, GENEVA, CH pages 1000 - 1004, XP371228 M. ZUKERMAN ET AL. 'A shared Medium Multi-Service Protocol' see paragraph 3 ---	1,7
A	EP,A,0 179 629 (INTERNATIONAL STANDARD ELECTRIC CORPORATION) 30 April 1986 see abstract ---	1,7
A	US,A,4 942 569 (J. MAENO) 17 July 1990 see column 4, line 57 - column 5, line 28 ---	1,5,7
A	EP,A,0 234 859 (AMERICAN TELEPHONE AND TELEGRAPH) 2 September 1987 see page 2, line 18 - page 3, line 25 -----	2,8

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No
PCT/CA 94/00554

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0276349	03-08-88	JP-C- 1673858	26-06-92
		JP-B- 3037360	05-06-91
		JP-A- 63196198	15-08-88
EP-A-0435046	03-07-91	DE-A- 3942977	27-06-91
		AU-B- 639961	12-08-93
		AU-A- 6786890	27-06-91
		CA-C- 2032774	01-02-94
		JP-A- 6209328	26-07-94
		US-A- 5173897	22-12-92
EP-A-0320772	21-06-89	DE-A- 3742939	06-07-89
		AU-A- 2668588	22-06-89
		CA-A- 1330119	07-06-94
		DE-D- 3888480	21-04-94
		ES-T- 2052679	16-07-94
		JP-A- 2004054	09-01-90
		NO-C- 173680	12-01-94
		US-A- 4926416	15-05-90
WO-A-9301670	21-01-93	US-A- 5268900	07-12-93
		AU-B- 652469	25-08-94
		AU-A- 2185892	11-02-93
		CA-A- 2112361	21-01-93
		EP-A- 0593534	27-04-94
EP-A-0179629	30-04-86	GB-A- 2166320	30-04-86
		FR-A- 2572606	02-05-86
		JP-A- 61129952	17-06-86
		US-A- 4707831	17-11-87
US-A-4942569	17-07-90	JP-A- 1221042	04-09-89
		CA-A- 1328916	26-04-94
EP-A-0234859	02-09-87	US-A- 4748620	31-05-88
		CA-A- 1276714	20-11-90
		DE-D- 3787817	25-11-93
		DE-T- 3787817	05-05-94
		JP-A- 62241454	22-10-87

THIS PAGE BLANK (USPTO)

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)